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ABSTRACT

A micro-economic model of population growth is presented to assess the relationship between education and fertility. On the basis of population growth evidence, the author presents the following opinions: (1) the potential of education as a policy instrument to influence family size is great but ignorance of the mechanisms through which education may affect fertility is also large; (2) economic policies that directly influence wife's wages, a couple's contraceptive behavior, and the early health and nutrition of children may be a more effective and quicker means of reducing family size than support of adult education; and (3) the trade-off that parents appear to make between the number of children they want and the investments they make in each child may be the key to middle- and long-term population policy in developing nations. The author concludes that the scarcity of economic resources makes continued research on policy instruments, like education, essential. A bibliography is included in the document. (Author/DB)

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POPULATION GROWTH AND EDUCATIONAL POLICIES: AN ECONOMIC PERSPECTIVE

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Dennis N. De Tray

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The Rand Corporation
Santa Monica, California 90406

POPULATION GROWTH AND EDUCATIONAL POLICIES: AN ECONOMIC PERSPECTIVE

Dennis N. De Tray*

The Rand Corporation
Santa Monica, California

March 1975

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I. INTRODUCTION

Social scientists have long been aware that as education levels rise, marital fertility declines. This relationship is statistically robust, of sufficient magnitude to be empirically important, and holds cross-sectionally, over time, and across countries. Further, it holds for parent education and family size and for child schooling and the number of siblings that children have. Given the pervasiveness and apparent strength of these relationships, it is natural to consider schooling as a potential policy instrument to reduce fertility in areas of rapid population growth. However, before large-scale efforts to increase either parent or child schooling are undertaken, a number of issues must be settled. Among these issues are:

1. Separating causation from correlation. It hardly need be said that a strong negative gross correlation between schooling and family size does not necessarily imply that public-policy-induced increases in parent or child schooling will cause parents to want and have fewer children.
2. Isolating "direct" and "indirect" avenues of influence. Historically, education has played many conceptual and empirical roles in models of fertility determination. Several of these roles imply that the link between education and fertility is indirect, working through such intermediaries as wage rates. If education's influence on fertility is mainly indirect, then it is possible that an alternative policy prescription that directly affects, say, wages would be a more efficient and effective means of slowing population growth.

3. Determining the type of schooling to promote. Faced by severely constrained resources, governments must know which policies will have the highest payoff in terms of family size reduction, policies promoting adult education or policies promoting child education. Similarly, curriculums and types of training that are most effective in reducing family size must be identified.
4. Determining the lag between policy implementation and fertility decline. Knowledge of this lag is essential if we are to assess the merits of education-related policies relative to other potential policies for reducing family size.
5. Assessing the conflict or complementarity of fertility-reducing educational policies with broader development goals.

A comprehensive analysis of each of the points listed above is beyond the scope of this paper and beyond the scope of my expertise. I have chosen, therefore, to concentrate on those areas in which my comparative advantage is greatest--that is, on assessing what the "new economics of fertility" and several recent econometric studies have to say about some of these points (much of which is not so new). However, in the spirit of this conference, I reserve the right to stray into research areas that are not well developed either theoretically or empirically, and to speculate on the policy significance of the missing theory or data.

Although I have tried wherever possible to draw out the policy implications of the work I am reviewing, this paper is considerably more "academic" than most other contributions to this conference. This emphasis is partly a reflection of my view that in deriving policy

implications from research we have often tried to run when we should have been learning to walk or sometimes even to crawl. I recognize that we cannot always afford the luxury of a long and careful learning period, but this seems the kind of forum in which the immediacy of tomorrow's policy decisions can be downplayed and we can turn to an in-depth review of the structure on which future policy may be based.

It is evident from recent literature that economists have found it convenient when discussing family size to view the household as a type of firm. This approach has been formalized in the so-called household production model and the major features, assumptions, criticisms, and strengths of this model are briefly reviewed in the first part of the following section; the remainder of Section II is devoted to a discussion of applications of this model to the study of family size determination. In Section III I consider the roles that education has played in the application of these models.

Although great concern over rapid population growth has been voiced by policymakers in developing nations, there has been a tendency for economists to turn to data from more developed countries, especially the United States, to explore and test their models of fertility determination. While the more limited and poorer quality of data in many developing nations may provide an explanation for this choice, the emphasis on fertility in developed countries does raise the question of the applicability of economic models of fertility to family size formation in developing nations. To supply a partial answer to this question, I discuss in Section IV the transferability of concepts presented in Sections II and III to a setting typical of conditions

found in developing nations. In this section emphasis is placed on the consequences of certain features of market economies in developing countries that may affect family size determination and investments in children; the quantitative importance of the link between child education and family size is also discussed. Section IV concludes with a brief discussion of research strategies to explore the links between education and fertility. The paper ends with a summary of implications for future research and for education and population policy.

Before proceeding I would like to make two points, although once made, I, and most of the other participants in this conference will ignore them. The first is that while this conference rests on the presumption that slowing population growth will increase a society's well-being, this presumption has never been adequately established either logically or empirically (see Krueger and Sjaastad, 1962; Robinson and Horlacher, 1971; and Blandy, 1974 on this point). The second is that even were we to know the direction in which governments should attempt to influence the demand for children, neither theory nor any foreseeable empirical work can supply us with a guide to the appropriate magnitude of government intervention. Without detailed information on individual preferences it is not possible to know if government intervention increases or decreases social welfare even when the appropriate direction of intervention is known.

II. ECONOMIC THEORIES OF FERTILITY

> The economic theory of household choice does not claim that each individual goes through an explicit calculus of pleasure and pain as a guide to behavior and this is certainly true when it is applied to fertility. It is recognized that the process each individual goes through is very complicated and varies among individuals. The assumption is that one possible way of capturing and making sense out of common elements of behavior is to derive propositions as if people were acting according to a specific rule--maximizing a utility function subject to a budget constraint. There is no guarantee, of course, that this is a good strategy. (Ben-Porath, 1974)

THE BASIC FRAMEWORK

Traditionally, when studying individual behavior economists have concentrated on the interface between the marketplace and household activities; this is particularly true for the allocation of time between these sectors. For all its potential shortcomings (see below), the household production model[1] has one major advantage: its very formulation recognizes and emphasizes that the word "leisure" is a poor description of much of the time that family members spend outside of

[1] Extensive discussions of the household production model are available in a number of sources. See especially Becker, Becker and Michael, Lancaster, Mincer, and Muth.

market work. Although classical consumer theory can in many cases accomodate the study of the intra-household allocation of time and resources, the language of the household production model encouraged economists to expand once again their analytical sphere beyond decisions on the amount of time to spend at market work and on which market goods and services to purchase.

In this model the family is viewed as a firm engaged in the production of basic items of consumption usually called "household commodities."[2] Families are assumed to produce household commodities by combining their own time with purchased goods and services. They obtain these goods and services in exchange for market work and income from other (nonwage) sources. Because of the close link between the production and consumption of household commodities--the process can, in fact, be considered one and the same in many applications of the model--commodities are not traded in the market place and thus have no explicit market price. However, since each uses up a certain portion of the household's scarce resources, each has an implicit shadow price that consists of the marginal per unit resource requirements (both time and market goods) valued at their opportunity cost. Finally, families are assumed, on average, to allocate resources available to them in such a way as to maximize the satisfaction they receive from those resources.

In models emphasizing fertility determination[3] families are said

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[2]As an example, the commodity "good health" may require as inputs doctor's services, drugs, a nutritious diet, and a person's time.

[3]Over the past decade economists have developed several models of fertility determination of the following type. See, for example, the papers by Ben-Porath, De Tray, and Willis in the March/April 1973 supplement of the Journal of Political Economy.

to maximize a (lifetime) utility function of the form

(1) $$U = U(c,s)$$

where c and s are, respectively, a measure of the services derived from children (both monetary and psychic)[4] and "standard of living," an aggregated bundle of all other items consumed by the household. For simplicity parents are assumed to make all fertility and consumption decisions during a single period although more recent applications of this model are beginning to incorporate the sequential nature of family size decisions (Heckman and Willis, 1974).

Commodities c and s are not directly available from the market, but must be produced within the household using the resources and technology at the household's disposal. Production functions for c and s may be written as follows:

(2a) $$s = s(t_{m,s}, t_{f,s}, x_s; E)$$

(2b) $$c = c(t_{m,c}, t_{f,c}, x_c, n; E)$$

where t_{ij} is the time input of the ith family member [i = m(husband's time), f(wife's time)] into the production of the jth commodity (j = s,c), x is an index of purchased inputs, n is the number of children a couple has, and E is a measure of the technology under which the household operates.

The model's emphasis on time as a productive resource in the household is, perhaps, its main departure from the traditional economic theory of consumer behavior. The production-consumption decisions of households at

[4]The assumption that child services and not children enter parent utility functions is a major departure from many previous models of fertility determination. This assumption suggests that parents may produce a given level of child services with different combinations of births and other child-related inputs, a possibility that underlies much of the following discussion.

any point in time, and over their life cycles, now depend not only on the prices of market goods and services that the household faces, but also on how "valuable" or scarce time is to the household.

A critical and often unstated tenet of this type of model is that "home time" (time of the husband and wife, and possibly of children) is a different input into the household production process than is "hired time" (maids, cooks, tutors, babysitters, and so on). Technically, this means that male and female time hired in the market place as an input in the household production never substitute perfectly for husband's or wife's time in that production process.[5]

For many individuals, one important factor determining the price or value of time is the market wage he or she foregoes when not engaged in market work. For people who work, exogenous (unanticipated) increases in market wages thus carry with them two effects. On the one hand, family wealth is increased and the household's demand for commodities increases; on the other, the price of one of the inputs into household commodities, family members' time, has increased, making commodities more expensive to consume. This second price effect is especially important for time-intensive household commodities, that is, commodities which require large inputs of time relative to other inputs. An often-cited example of such time-intensive commodities is the "production" of children.

The concept of differing technologies (E) among households is partly an expression of ignorance about the internal workings of families just as appeals to differing technologies among firms and to changes in

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[5]If hired and own time did substitute perfectly, there would be no need to distinguish between them in household production; commodity production functions could then be written as a function of x only [for example, c(x), s(x)].

technologies over time are often expressions of ignorance of underlying market production and growth processes. Partly, however, the introduction of different technologies among households is a means of recognizing that some people may be relatively more efficient at running their "firms" (households) than are others both in general and with respect to performance of certain specific tasks. Efficiency in contraception and early investments in children are two important examples of this effect and are discussed in detail below.

The quantities of s and c produced will depend not only on production technologies and tastes as embodied in the utility function, but also on the scale at which households operate. The scale of household operation is defined by the "full wealth" available to families. Full wealth is a broader concept of income than the concept sometimes used in consumer demand theory, and includes the value of all family resources whether they enter the market place or not. If we ignore the value of child time and assume further that the value of husband's and wife's time is constant over their life cycle, a family's full wealth (R) may be written as:

$$(3) \qquad R = (w_m + w_f)T + V = w_m \sum_j t_{m,j} + w_f \sum_j t_{f,j} + p\sum_j x_j$$

where w_m and w_f represent the value (price) of husband's and wife's time, T is the total time available to each member of the household, V represents nonwage sources of income, and p is the price of market goods.

Although the concept of full wealth is straightforward in theory, it is often difficult to operationalize. One of the major problems in arriving at an acceptable measure of full wealth in fertility-related studies involves the value of the wife's time. First, for wives who do not work there is no simple way of measuring the value of their time;

second, even if a wife does work, her current wage is likely to depend on her previous labor market experience, which, in turn, will depend on the number and spacing of her children. Thus, causation flows both from the value of a woman's time to the number of children that she wants, and from the number of children that she has to the value of her time. Recent advances have been made (see, for example, Heckman 1972) that show promise in eventually solving these problems, but for the moment they remain a serious obstacle along the path from economic theory to econometric modelling of fertility decisions.

The "demand" equations for child services and for standard of living [$c(\cdot)$ and $s(\cdot)$] derived from this model are of the usual form in which prices (of both market goods and of household time), income, and some measure of household technology determine the levels of these commodities. For example,

$$s = s(w_m, w_f, p_x; E) \tag{4a}$$

$$c = c(w_m, w_f, p_x; E) \tag{4b}$$

In this theory, like many other economic theories, generality carries with it the price of ambiguity. In a sense, unless we already know something about the child services production process, economic theory in and of itself produces little in the way of refutable hypotheses. Without further restrictions on the model, the predicted effect of, say, a rise in the value or price of the husband's or wife's time is ambiguous (see below) and, therefore, in its most general form the model may not be rejectable.

The value of this unrestricted theory is that it supplies a

convenient language in which to discuss issues of fertility determination, and to some extent it promotes a more careful and logical discussion of casual statements about these determinants. How one goes about restricting this general model depends critically on the subset of issues toward which a particular research effort is directed.

Detailed derivations and discussions of these derived demand curves (Eq. 4) have been presented elsewhere (De Tray, 1973; Willis, 1973) and to repeat them here would serve little purpose. To summarize, the effect of a change in a price variable, say the wife's wage, depends on the following factors:

1. The relative importance of the wife's time in various household activities (c and s in our model);
2. The (current) allocation of wife's time between market work and home production;
3. The ease or difficulty with which other inputs available to the household can be substituted for wife's time in the production of household commodities;
4. And finally, how fixed or variable the family is in its consumption patterns.

The relative time intensity of different commodities determines the effect of an increase in wife's wage on the marginal cost, and therefore the relative price, of each commodity. Time-intensive commodities, as children are thought to be, will experience relatively large price rises, which in and of themselves will cause parents to desire less of those commodities.

The current allocation of the wife's time determines the "income effect" associated with an increase in her wage. For those hours allocated

to non-market activities, an increase in market wages has two offsetting effects. On one hand, the value of that time to the household has increased; on the other, the cost of household commodities using that time has risen. It can be shown that these two effects exactly offset each other and, therefore, that an increase in market wages affects a family's full wealth only to the extent that husbands and wives work in the marketplace (De Tray, 1973).

The third point has to do with the production technology under which the household operates. In some household activities husband's time or purchased goods or services may be very good technical substitutes for wife's time while in others there may be few or no reasonable alternative inputs to her time. An example of the first activity is dishwashing, and of the second, breastfeeding. Those commodities in the production of which wife's time has few good substitutes will tend to increase in price (marginal cost) relatively more than commodities with production processes in which wife's time has many good substitutes.

The fourth point is a roundabout way of bringing tastes into the picture. If families have strong preferences for certain consumption activities (inelastic demands), changing prices will have relatively little effect on consumption levels; where preferences are not so strong (demand is more elastic), price changes will have larger effects on consumption levels.

Symbolically, the total effect of an increase in wife's wage on, say, the consumption of child services (points 1 through 4) can be written in elasticity terms as:[6]

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[6]See De Tray, 1973 for the derivation of this Eq. 5. The elasticity of i with respect to j is the percentage change in i divided by the percentage change in j.

(5) $$\frac{w_f}{c}\frac{\partial c}{\partial w_f} \equiv \eta_{cw_f} = \eta_{cR}\frac{e_f}{R} + k_s\sigma_{sc}(k_{fs} - k_{fc})$$

where η_{ij} is the elasticity of i with respect to j, e_f/R is the share of wife's market earnings (e_f) in full wealth, k_s is the share of family expenditures on s in full wealth, σ_{sc} is the elasticity of substitution between s and c in utility space, and k_{ij} is the share of input i in total cost of output j. The first term on the right hand side thus represents the pure wealth effect of increasing wife's wage. Although some empirical evidence suggests otherwise, η_{cR} is usually assumed to be positive but small. The share of wife's <u>market</u> earnings in full wealth is also not likely to be large on average either in developed or developing nations, and so the income effect associated with an increase in a wife's wage rate (point 1 above) is likely to be quantitatively small.

The second term captures both substitution in consumption and substitution in production effects (points 2, 3, and 4 above). The elasticity of substitution between s and c (σ_{sc}) will be positive if child services and standard of living are substitutes in consumption. The sign of this term will, therefore, depend on the sign of $(k_{fs} - k_{fc})$. If child services are relatively time-intensive, k_{fc} will exceed k_{fs} and an increase in a wife's wage will reduce desired fertility. A numerical example of the offsetting influences of these income and substitution effects is given in Section III.

One of the most sophisticated and comprehensive extensions of this general model has been proposed by Robert Willis (1973). Two features distinguish the basic structure of Willis' model. First, the

production relationship for child services is assumed homogeneous of degree 1.[7] Under this assumption the production of child services can be characterized equally well by Eq. 2b or by:

$$(6) \qquad c = n \cdot \hat{c}(t_{n,c}/n,\ t_{f,c}/n,\ x_c/n;\ E)$$

Child services may thus be thought of as numbers of children (n) times some transformation of average investments (inputs) per child ($\hat{c}$) or as $n \cdot q$ where q is quality per child ($= \hat{c}$).

A second feature of Willis' model is that, to permit differential effects of income on n and q, each component of child services enters the utility function directly and Eq. 1 becomes

$$(1') \qquad U = U(n,q,s)$$

Although the main purpose of the homogeneity assumption in economic models is often analytical tractableness, Becker and Lewis (1973), and Willis have suggested that if the assumption holds, it may have important implications for the estimation of derived demand equation for numbers of children. Willis' model implies that parents will always want to invest equal amounts in each child they have. One implication of this result is that under reasonable assumptions about relative income elasticities of n and q, the observed relationship between n and income (holding wages and the price of market goods and services constant) could be negative even if the "true" or marginal-cost-constant income effects were positive. A heuristic interpretation of the Becker-Lewis discussion is that holding prices of inputs constant there exists a positive relationship between income and the marginal

[7] That is, an n% increase in all inputs will result in an n% increase in output.

cost of, say, n and further, that the extent of this relationship depends on the level of q that parents invest in their children.

Although an interesting example of the possibly unintended side effects of an assumption, the policy implications of the points stressed by Becker and Lewis are not obvious.[8] Further, it is not at all clear that the income-related implications stressed by Becker and Lewis are empirically distinguishable from a simpler model that recognizes the possibility that numbers of children may be inferior inputs into parents' utility functions. At minimum, the Becker and Lewis arguments suggest that estimating negative income effects holding input prices constant may not imply that children are inferior goods in the economic sense of the term.[9]

CRITICISMS

"The main shortcoming of the 'new home economics' for the analysis of fertility decisions is that it assumes too little. The basic postulates...do not distinguish children from hi-fi sets!" (Griliches, 1974)

Economic models of fertility based on the household production

[8] For another example of the cost of assuming homogeneous of degree 1 production functions, see De Tray, 1973. In that model child services are assumed to be produced by a linear homogeneous production which has as arguments numbers of children and total investments in children. An implication of this formulation of the model is that the income elasticity of investments per child is zero. That is, increases in income result in equiproportional increases in numbers of children and total child investments. Although aggregate data did not reject this form of the model, subsequent work using more appropriate individual-level data did.

[9] Other forms of this argument have been suggested by Leibenstein (1957), and Duesenberry (1960) and in some respects the Becker-Lewis model is a formalization of these earlier discussions. Warren Sanderson (1974) offers an interesting history of economists' efforts to analyze fertility which links the earlier works of Leibenstein and Easterlin to the models of Becker and Lewis, and Willis.

model have been criticized on a number of fronts by economists (Leibenstein, 1974; Nerlove, 1974; Griliches, 1974) and non-economists alike (Blake, 1965; Namboodiri, 1972; Ryder, 1973).[10] For example, Namboodiri (1972) and Ashenfelter (1973) have raised the question of whether economists' models of fertility are too general and too simple to be useful analytical tools. Griliches (1974) argues in a similar vein that in order to advance economic analysis of fertility we need to "return to the basics," to try to understand the motives that families have for producing children. He suggests several (reciprocal caring, immortality via one's offspring, and so on) that may indeed be worthy of study in the future; few economists would argue, however, that a detailed knowledge of the utility-yielding characteristics of a good is essential to study the demand for that good.

Along the same lines, I suggest that we can contribute (and have contributed) significantly to the explanation of household fertility behavior without knowing explicitly why it is that parents have children. One of the important contributions economists have made to the study of fertility is exactly that they have treated children as they would any other household commodity. This has led to a theoretical model with few unambiguous predictions, but one that emphasizes the many important <u>empirical</u> questions that must be answered if we are to understand the socio-economic determinants of fertility.

In their application of the household production model, economists have been accused of ignoring exactly what they are purporting to study:

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[10] I consider here only a subset of those criticisms since many of them have been adequately and articulately discussed by Yoram Ben-Porath (1974).

the family and family formation. Technically speaking, in applying the household production model to the study of such areas as the demand for health and family formation, economists have been criticized for assuming a single household utility function and therefore, bypassing the issue of interdependent utility within the family (Ryder, 1973; Nerlove, 1973,74; Griliches, 1974). Further, critics have pointed out that most applications of the household production model assume that production processes are strictly separable in the sense that joint production is not a factor in determining resource allocation and output levels (Nerlove, 1974).

Problems that arise from the assumption of the single utility function are discussed in detail by Nerlove (1974) and Griliches (1974) and center on (1) whether children are arguments in some parental utility function, or partial formulators of the family's overall utility function and (2) just what it is about children that enters parents' utility functions, child utility or actual child behavior.

Regarding the first point, how far off we are in assuming a single utility function depends on two factors--the question being asked, and the potential differences among individual utility functions within a family. If we are principally concerned with the number of children a family chooses to have, the prospect that children's preferences for siblings directly influence parental fertility decisions seems remote. On the other hand, parent investments in children clearly depend on child cooperation and to that extent on the child's own objective function.[11]

[11]Griliches suggests the possibility that in the U.S. the potential for substantial differences in objectives led to current-generation parents' disenchantment with children and hence to the rapid fall in birth rates in the '60s and early '70s. This can be interpreted as a kind of extended Easterlin hypothesis (Easterlin, 1968, 1973) whereby the current child-producing generation bases its expectations on the closeness with which parent and child objectives will match on their own experience with their parents.

Whether children actually alter (shift) the family utility function or whether their actions (or utility) simply affect the level of parent utility is open to question; so, too, is the issue of whether these alternative hypotheses can be distinguished empirically. At least for now, I will continue with the assumptions that (1) children affect utility levels, but not utility functions; and (2) on the average, either parent expectations about future child behavior and cooperation are unbiased, or if expectations are biased, the bias is unrelated to other variables of interest in the model (wages, income, education, and so forth).

Interdependent utility is considered by Becker in his formulation of a marriage model (1974). In that model he shows that "caring" between family members is a sufficient condition for assuming that the family behaves as if it has a single utility function. Griliches' objections to this formulation are along the lines considered above (whether or not children shift utility functions) and need not be rediscussed.

The last of the criticisms mentioned above concerns joint production. Nerlove (1974) has argued that most applications of the household production model have ignored not only the possibility of common overhead inputs (that is, nonseparability of certain inputs) but the more important possibility of complementarity among different consumption outputs. Nerlove's particular example concerns investments in health which may increase the level of production of other dimensions of child quality, for example, education (as opposed to schooling) with no additional expenditures on schooling. At a later point in this paper I argue that this may indeed be the case; if it is, a link can be drawn between early

home investments in children and later public schooling investments which may be useful in explaining child investment strategies adopted by parents in developing nations.

III. EDUCATION AND FERTILITY

Based on the preceding discussion, one might well question the relationship between the title of this paper and its contents. The reason for the omission of specific references to education to this point is that education enters the picture as one begins the move from conceptual model to either empirical test or policy implementation. The value of an abstract discussion of "economic" influences on fertility is that it acts as a guide to direct our attention toward points in the fertility-determination process at which such policy-responsive variables as schooling may affect final outcomes. Although many of these points are not new either to demographers or to other social scientists, models like the one presented above do help clarify the potential complexity of education's role in influencing family size. Economic models of fertility have also served to highlight one important role of education that has previously received only minimal attention in policy circles: the potential tradeoff between family size and child schooling.

PARENT EDUCATION

Past studies have linked the education of parents, especially mothers, to the number of children they have and to other aspects of family behavior through many paths. Education in both the narrow sense of formal schooling, and in the broader sense of human capital is thought to influence tastes by exposing people to alternative life-styles and improving information on the set of choices available to people (Easterlin, 1973, and others). It has been shown to affect the value

of an individual's time in the market place; there is weaker evidence that it may also play a similar role in influencing the value of non-market time; and education may partially determine how well couples perform certain specific tasks--in this context important examples are contraception and early (pre-school) investments in the human capital of children.

Market Effects

Researchers have long recognized education or years of schooling as one of the primary inputs into the human capital earnings function (Ben-Porath, 1973; DaVanzo, 1972; Easterlin, 1973; Harman, 1970; Schultz, 1970,72; and others). In this capacity education is assumed to have two indirect effects on a couple's desired family size, one, through its effect on the opportunity cost of the time required to have and rear children, and the other through its effect on the total wealth (resources) that a couple has at its disposal. If children are time intensive the first of these effects is predicted to reduce a couple's desired fertility while the second should increase desired fertility if children are in an economic sense normal goods.

One of the few low-income-country studies that contains the information necessary to assess the quantitative importance of education effects via market wages is DaVanzo's 1972 work on family formation in Chile. DaVanzo uses 1960 age-specific data on 25 provinces in [redacted] subdivided into urban and rural areas to estimate a simultaneous-equations model with female labor force participation, female wage, marital status, fertility (children ever born) and child labor force participation/school attendance as the endogenous variables in the system.

These equations allow us to trace the effect on fertility of years of schooling through market wages and family income. To simplify matters, and because this example is primarily illustrative, I will restrict the discussion to effects of changes in female education.

Education's "price" effect on fertility through wife's market wage can be conveniently expressed as the product of two elasticities, one measuring the responsiveness of market wages to changes in schooling levels, and the other the responsiveness of family size to changes in market wages. In DaVanzo's Chilean sample, the elasticity of wages with respect to schooling was approximately 1.1 for women ages 40 to 44 in 1960.[12] At the mean schooling level of 4-1/2 years for this group, this elasticity implies a rise in female wages of about 20% for each additional year of female schooling.

For the Chilean sample the second elasticity, that of numbers of children ever born with respect to the wife's wage, is -0.36. Thus a 10% (exogenous) rise in a woman's market wage is projected to reduce births by 3.6%. To calculate the implied elasticity of family size with respect to wife's education as it works through her market wage, we multiply together the two elasticities given above (1.1 and -0.36), which results in an elasticity of approximately -0.4.

The calculation of a wealth effect of a rise in female education is considerably more complicated, requiring a number of assumptions since DaVanzo's fertility equation contains no direct measure of family income or wealth. In order to complete this example, I will assume

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[12] In addition to female wage rates, other variables included in the children-ever-born equation were marital status, child labor force participation or child schooling, male wage rate, infant mortality, and an urban residence dummy.

that (1) husband's time generates only market income and thus changes in husband's wage affects only family income (and not relative prices of consumption) and (2) the husband's contribution to family full wealth is 0.5, and the wife's contribution via her market earnings is 0.2.[13]

DaVanzo finds that the elasticity of children-ever-born with respect to husband's wage is 0.08; this figure can be interpreted as the income elasticity of children weighted by the share of husband's earnings in full wealth implying a full wealth elasticity of 0.16. The income effect of an increase in wife's wage is this full wealth elasticity weighted by the share of wife's market earnings in full wealth, or 0.03 (=0.16 x 0.2).

To summarize, if we consider only education's effect on market earnings, a 10% increase in female schooling (approximately half a year in Chile in 1960) will have two partially offsetting effects on family size: a "price" effect that reduces children ever born (at mean levels of family size) by 15 children per 100 couples; and an "income" effect that increase children ever born by 1.3 children per 100 couples. The net effect is thus a reduction in children ever born of about 14 births per 100 couples, or a reduction in average family size of 3.8% (from 3.637 to 3.497 children ever born).

This example is over simplified, but it does serve to identify part of the process necessary for a full evaluation of the influence of education on fertility. Whether the calculated effect should be

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[13] This implies that wife's non-market time and non-wage sources of income account for the remaining 30% of family full wealth.

considered big or small depends, of course, on the cost of increasing schooling, and the costs and fertility responses of alternative schemes for lower family size. Also, schooling may benefit development objectives in ways other than through its effects on family size; thus, the process of evaluating the relative merits of plans to increase, say, female schooling levels as a fertility reducing policy is, indeed, complex. Finally, it should be noted that while the Chilean data have some shortcomings for the study of family behavior, we will not be nearly so lucky when it comes to evaluating the quantitative effect of other avenues through which adult education is thought to affect family size decisions.

Non-market Effects

The effects of education on the productivity and allocation of non-market time and on household information levels have recently been stressed by several authors (De Tray, 1973; Grossman, 1972; Leibowitz, 1974; Michael, 1972,73). The gist of these arguments is similar to the argument given for the education-market wage relationship: increased schooling raises the level of effectiveness (efficiency) with which people use their non-market time in general and with which they perform certain specific tasks. In other words, just as education is thought to increase a person's marginal product in the market place, it may also increase the marginal productivity of time in non-market activities. For many issues, distinguishing this effect of education on family behavior from education-related effects that work through changes in tastes may not be possible. But there are at least two areas in which it is important to distinguish between taste and efficiency

hypotheses. These are the effect of education on contraceptive use and the relationship between parent education levels and early human capital investments in children.

The relationship between education and contraception has been explored in detail by Michael (1973) and Michael and Willis (1973).[14] Michael's discussion of education and fertility control provides a useful summary of both past studies in this area and generally accepted views:

> It has long been argued that more-education couples have greater access to fertility-control information and are therefore more successful in preventing unwanted pregnancies. Indeed, there is considerable evidence, from sociological surveys in the United States...that...more-educated couples do use contraceptive techniques more extensively, approve of their use more thoroughly, and adopt contraception at an earlier birth interval...
>
> Similar findings are reported for other countries as well. Yaukey (1961) finds [in Lebanon]...that the use of contraception and particularly the use of appliance methods rise with education. Roberts

[14] Both Ronald Freedman's and Marcelo Selowsky's comments at this conference bear directly on this issue. Freedman argued that at least for Taiwan and Thailand, recent evidence does not support the view that the negative correlation between education and fertility is due entirely to better contraception by the more educated. His point that family planning is a complimentary input into any scheme to reduce the demand for children is also well taken.

Selowsky commented on the possibility that the relationship between observed fertility and parent education could be the result of proportionally more "unwanted" births for poorly educated couples.

> et al. (1967) found that general knowledge of contraception, the average number of contraceptive methods known per woman who knew of at least one method, and the percentage who had ever used contraception rose with the woman's education level [in Barbados]. Broadly comparable findings for India (see Dandekar [1967] and Morrison [1957]), Puerto Rico (see Stycos [1967]), Japan (see Matsunaga [1967]), and Ghana (see Caldwell [1967]), for example, offer supporting evidence of greater use and acceptance of contraception among the relatively better-educated. (Michael, 1973, pp. S140-S141.)

As with any commodity, the observed amount of contraceptive knowledge and use depends on both supply and demand considerations. If we ignore factors affecting the demand for children, the implication of the findings cited by Michael is that households with little education have a higher probability of producing "unwanted" children--that is, of having more children than they would have had with "perfect" contraception. A corollary to this is that if policymakers wish to reduce future population growth they need only increase the level of education in general and contraceptive knowledge in particular or subsidize the use of contraceptives.

At least in developing nations, this policy has not always worked as predicted. Although acceptance rates for new forms of contraception are often high when these forms are first introduced, the effect on

birth rates was sometimes significantly less than the acceptance rates implied.[15] One explanation for this result is that many acceptors are substituting one form of contraception for another rather than using the new forms of contraception to reduce fertility. If this is true, it raises the question of whether it is education itself or education's correlation with birth control knowledge and efficient birth control use that results in the observed negative relationship between education and fertility (for a more detailed discussion, see De Tray, 1973 and Gardner, 1973).

The major confusion in interpreting and assigning causation to the education-contraception relationship lies in the fact that past studies have usually failed to adequately control for the demand for contraceptive knowledge. How much contraceptive knowledge a couple wants should depend in part on how much they plan to use that knowledge. Put another way, a household's demand for contraceptive knowledge is derived in part from their desires for numbers of children (or to restrict those numbers).[16] The more children they want the less valuable contraceptive knowledge may be to them and the less they will demand. Therefore, before we can assess the role that education plays in determining the ability of families to control their supply of children, we must have a theory of the demand for contraceptive knowledge that takes into account the fact that some families may want more knowledge and some families less. Even were such a theory available, few data sources are rich enough to allow identification of both the supply and the demand for contraception

[15] Schultz (1972); see also, Freedman et al., (1974), p. 275.

[16] As Freedman pointed out in his comments, desires to regulate spacing may also affect the demand for contraception.

or contraceptive knowledge. The upshot of all this is that policymakers may have to wait some time before they have at their disposal information adequate to judge the relative merits of contraceptive-promoting schemes aimed at reducing population growth.

Michael and Willis offer some preliminary evidence on the contraception-education link for the U.S. population. After first classifying contraception into good (pill, IUD, condom and diaphragm), poor (all other types), and none, they find that when female education levels are held constant, the major effect of "better" contraception was to reduce variances in live births;[17] they conclude, however, that "contraception use had no significant effect on mean numbers of live births" (p. 53) when wife's education level is also included in the regression. Wife's education, on the other hand, is negatively related to both the level and variance of live births.

Similar results seem to hold for "unwanted births": although results were erratic, higher female education (holding contraception constant) was generally associated with fewer births classified as unwanted (see also Ryder and Westoff, 1971, on this point), whereas little systematic relationship existed between better methods of contraception and unwanted births (holding female education levels constant). Finally, female education was found to be positively associated with probability of adoption of the pill, but not as strongly as was husband's predicted income.

How one interprets these scattered findings depends on the role one assigns to female education. I would argue (speculate) that they point toward a couple's demand for children as a prime determinant of choice of

[17] Regression observations were cell means.

contraceptive technique. The reason is, of course, that I consider female education as an important determinant of a couple's desired family size, rather than as a factor in the "production" of effective contraception. Others may argue that the Michael-Willis results reflect either taste factors such as willingness to accept and to use (new) contraceptive devices or as a measure of knowledge about alternative contraceptive techniques. While the case surely remains open, it seems to me that evidence is accumulating on the side of the "demand" hypothesis.

Does it matter, for policymakers in developing nations, whether female education works through wage rates and household efficiency on the demand for children or, say, through tastes? As usual, the answer depends on the context in which the question is asked. If we are interested in assessing the value of further investments in female schooling, one return that should enter the calculation is the reduced average family size that such an investment might bring about. This is a legitimate benefit whether education works through demand or through tastes. If, however, the objective of policy is directly to reduce population growth rates, matters become more complicated. Policymakers are faced with a number of options, and to choose among them requires knowledge about the education-contraception link. For example, funds might be best spent subsidizing and promoting contraception if the "tastes" and "knowledge" hypotheses are correct; if demand considerations are at work, then policies affecting female schooling levels must be compared to alternative ways of reducing couples' demand for children.

Several authors, including myself, have argued that another major link between fertility and education is through the effect of parent education on couples' ability to invest in their children. In its simplest

form, the argument is that the more highly educated parents are, the more efficient and effective they are at investing in their children during pre-school years. This increased efficiency reduces the relative price of early investments in children which, in turn, increase the quantity of pre-school human capital that parents instill in children. The picture may be extended by recognizing that early investments in children are likely to be complementary with later investments that the children themselves make; that is, we expect a positive association between early investments in children such as health and later investments such as formal schooling or other types of training.

Although the language may be different, this relationship between certain parent characteristics and the characteristics of their children is a relatively old one to both social scientists and to policymakers. The well-known work of Blau, O.D. Duncan, Beverly Duncan, Featherman, and others on occupational mobility between generations is in this vein;[18] and, in the United States, the Office of Economic Opportunity's Headstart Program was a recognition that some children arrive at the school door with a considerable handicap in terms of their accumulated human capital investments. The quantitative importance of this relationship for family size is not well established, but preliminary evidence using U.S. data (De Tray, forthcoming) suggests that it may be among the most important avenues through which parent education works to influence fertility.

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[18]For an extensive bibliography of work on occupational mobility, see Duncan, Featherman and Duncan and the references contained therein.

CHILD EDUCATION

In several recent studies, economists have argued that one of the factors influencing family size is the characteristics that parents expect or want their children to have.[19] If parents care about such things as sex of children and innate mental and physical health of children, deviations between expected and actual characteristics of progeny may affect couples' completed fertility (Ben-Porath, 1973; Ben-Porath and Welch, 1973; and Welch, 1974). Although of some interest to policymakers since the not-too-distant future may bring a significant reduction in the uncertainty associated with the sex of unborn children, I want to concentrate here on the interplay between the number of children parents have and the human capital parents want to invest in their children.

Although possibly a poor choice of terms, this interaction between numbers of children and their characteristics is usually called the "quantity/quality" tradeoff (Becker, 1960; De Tray, 1973; Willis, 1973). The argument proceeds roughly as follows: Parents first determine what level of family resources they want to devote to producing child services; they do this based on the utility they expect to receive from the services (psychic and monetary) that children supply and on the cost of factors (time and purchased goods) that enter the production of those services. Parents then decide how these resources are to be allocated between the number of children they have and the amount of resources they "invest" in each child.

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[19] Of course, demographers have long recognized that parents may want, say, boy children more than girl children and that uncertainty in achieving this goal may affect family size.

Parents divide resources between numbers of children and investments in children based on the relative expense of producing numbers and quality, and on the effectiveness of each component in generating child services (that is, the relative marginal products of quantity and quality). "Child services" is intentionally an abstract and loosely defined concept, but it is possible to operationalize it along one of several related lines. For example, in the context of less developed nations, and even perhaps among the lower income portion of the U.S. population, one could argue that parents, in producing and investing in children, want to maximize the pool of income their children produce. Thus, for a given resource allocation they face a tradeoff between a large number of children with relatively low income-earning potential (low investments per child), and fewer children with relatively high earning potential. Depending on the rate of return to human capital, the value of "raw" labor, and the expected survival rate of each child (O'Hara, 1972), parents will determine an optional quantity/quality investment strategy.

Although the evidence is preliminary, there has been some empirical confirmation of the hypothesis that parents may substitute investments in children for numbers of children. In general, higher rates of school enrollment for children or more years of completed schooling appear to be associated with lower completed fertility in both U.S. data (De Tray, 1975), and in several developing nations (DaVanzo, 1972; Schultz, 1969,71). If subsidizing investments in children would reduce parents' demand for numbers of children, then exploiting that relationship is a particularly appealing policy option since it should also have the effect of increasing per capita education and earnings of future generations. These and related issues are pursued in depth in the following section.

IV. APPLICATION TO DEVELOPING NATIONS

In this section the focus of the discussion narrows to consider the application of some of the concepts presented above to a "typical" developing nation. The severe constraint on public resources faced by most developing (and developed!) nations dictates that we consider first the issue of the expected level and timing of the payoffs to various policy options. In this context, it is useful to view policies affecting adult education and policies affecting child education as competitors for public funds. As we will see, the environment in which these alternative policies are expected to work in LDC's will play a critical role in determining their relative payoffs.

ADULT EDUCATION POLICIES

Adult educational policies are those policies that affect couples in the current child-bearing generation. These policies are presumed to take advantage of the negative association between parent education and fertility to affect a reduction in average family size. As the previous discussion has indicated, the mechanisms through which adult education influences fertility are complex, and their quantitative importance is not well established for developing nations. Further, adult education may be too "blunt" a policy instrument in that policies aimed directly at, say, increasing female wages may produce a larger reduction in population growth rates per unit expenditure than policies that indirectly increase female wages through improved opportunities for schooling.

A judgement as to whether these shortcomings are relatively worse for adult education as a policy instrument than for child education would be only speculation at this point, but when we turn from the

benefit (fertility-reducing) side of the picture to the production side (private and social) we are on firmer ground. The human capital literature has stressed three aspects of the education investment process that are pertinent here: first, the principal private costs of acquiring schooling are the income earning opportunities foregone; second, the value of a given unit of education depends on the number of years over which returns are received; third, external capital markets in which investments in human capital can be financed seldom exist.

Each of these points suggests that adults may find it more costly, less rewarding, and more difficult to invest in themselves than to invest in their children. Parent time is worth more than child time; young children face a longer investment recoupment period than adults; and, the only source of (internal) financing for human capital investments may be a couple's current market earnings. This last point is especially important in situations where nonmarket sources of income and savings are minimal.[20] The net result of this is that governments may find that a substantially higher subsidy is required to induce parents to invest in themselves than is required to induce parents to invest in their children.

A final point on the riskiness of adult education policies concerns the lag between policy action and parent reaction. Although some progress has been made in determining fertility response lags (Schultz, 1972), we know almost nothing about the length of time it would take for a policy-induced increase in adult education to filter through to a reduction in

[20] Extended families may alleviate this financing constraint somewhat, but the direction of the effect will be unchanged.

fertility. Data requirements to supply this missing information are stringent and we can only speculate that the process is unlikely to take place very rapidly. Such policies may therefore be untenable because interim population growth rates would be unacceptably high.

CHILD EDUCATION POLICIES

Policies that increase the amount of schooling children receive may affect population growth rates in two ways, one through the effect of increased child education levels on parent's desired family size, and the other, a much longer term effect working through children's desires for progeny when the children, themselves, become adults. Here I will concentrate more or less exclusively on the first of these effects because of its potential for a relatively short response lag and mention only briefly considerations having to do with the second effect.

Policies affecting child education are one avenue through which governments can influence parents' decisions on desired levels of quantity and quality of children. There are, of course, other means of influencing this decision and several recently suggested policy options and pilot programs are implicitly aimed at this trade-off. Tied incentive schemes that penalize parents who have "too many" children (Ridker, 1971; Finnigan and Sun, 1972) raise the cost to parents of having an additional child relative to investing more in existing children. I am sure that this information would not come as news to the authors of these proposals, but viewing these efforts in the context of the more general model discussed above emphasizes the fact that couples have in a technical sense always had this option

at their disposal. That parents appear to have chosen many children and relatively low investments per child is a fact worthy of careful consideration. Solving this puzzle may do much to further economic development in general and the goal of reducing population growth in particular.

Children as Capital (A digression)

The issue of the "rationality" of low-income parents who have many children depends in part on answers to the following questions:[21] What is it about low-income, traditional economies that might lead parents to use children as a means of transferring income from one time period to another; and, in this same setting, what is it about child rearing that induces parents to have many children and invest little in each.

With regard to the first question, I suggest that lack of market alternatives, poorly developed or nonexistent capital markets, and a set of factors associated with the relative riskiness of investment alternatives are conditions sufficient to make children an attractive form of capital in most developing nations. Developing nations are characterized by a limited set of long-term investment possibilities and old age support programs with, perhaps, land as a main alternative to children. Without substantial initial wealth, however, land purchases require a working long-term capital market. Children, on the other hand, have relatively low "down payment" requirements, and their full cost

[21] Although I am convinced that there are consumption benefits to having and rearing children even in developing nations, I will ignore them in this discussion.

to parents is automatically and conveniently spread over a 10 to 15 year period. Further, in the relatively unsettled political climate of some developing countries, children represent an asset with a fairly low probability of confiscation, and, especially within the framework of an extended family, a fairly high probability of yielding returns.

But what of the negative rate of return to children that Enke (1960) and others claim to have found? In one important sense, this point by itself is immaterial. It is quite possible that the rate of return on children could be zero or negative and that children could still represent the best capital investment when compared to available alternatives. The point is a simple one, but easily overlooked: children may be good capital investments because, when compared with alternative investments they yield the least negative return.

The second question raised above concerns the type of child capital in which parents invest. In the context of the model presented in Section II, the basic determinants of this decision are the relative rates of return to human capital, especially schooling, and to "raw" labor. Several factors that may affect these rates of return were mentioned in Section III (for example, parent education); however, two issues remain, one concerning the role of mortality rates and the other the role of inputs complementary to schooling.

In his excellent theoretical piece on infant mortality and family size, Donald O'Hara (1972) found that without some knowledge of the underlying parameters, the theoretical relationship between infant mortality and births was ambiguous:[22] the model did, however, predict

[22]That is, economic theory alone does not predict whether a decrease in infant mortality will increase or decrease birth rates.

unambiguously the relationship between infant mortality and the desired level of investments per child. In regimes of high infant mortality, parents will tend to spread their child-related investments over many children because of the high risk associated with investing large amounts in any one child.[23] As mortality rates fall, parents shift from numbers-intensive portfolios to more investment-intensive portfolios.

Mortality levels depend partly on community factors and partly on such factors as hygiene and nutrition over which parents have some control (see the Butz and Schultz papers in this volume for a detailed discussion of this point). O'Hara's work suggests a strong positive relationship between these health investments in children and later, school investments; it also suggests that parents may resist shifting their child capital portfolio into schooling unless the requisite early investments in health have been made either privately or publicly. The payoff to policies that recognize this complementarity may be considerably higher than policies that concentrate action in one area or the other.

Policy Options and Potential Effects

Let us assume that children are considered by parents as having good capital/asset characteristics. Given this, the case for policy intervention to influence investments per child seems strong. Such policies take advantage of the superiority of children as investment

[23]This risk factor and the fact that children come in discrete quantities could be responsible for the relatively high desired family sizes in less developed countries. Say a couple wants to be 90% sure of having an economically successful son. If the probability of success for each son were in the range of .7, which does not seem unreasonable, two sons would be required to achieve the .9 probability of one successful son. This implies a mean number of living children on the order of four and four living children per couple represents a very rapidly expanding population.

goods; introducing new investment opportunities, on the other hand, might entail a considerable lag between government action and behavioral response while couples learn about the payoff and risk characteristics of the new options. With children, policymakers face only the problem of how to influence the "type" of child parents want.

An obvious source of influence are policies related to public education and health services. The unanswered questions in this regard are whether such policies, as they would probably have to be instituted in developing nations, might not be pro-natalist rather than anti-natalist,[24] and whether these policies can be expected to have much quantitative effect on fertility levels.

The potential for pro-natal effects of public education results from the implicit income effect[25] of these policies and the possibility for parents to increase their consumption of child services relative to their current standard of living. If desired numbers of children are relatively unaffected by pure changes in income as scattered evidence seems to indicate (DaVanzo, 1972; De Tray, 1973, 1975; Michael, 1971), then a policy that reduces the price of investing in children can induce parents to have fewer births and invest more in each child. Technically, this will occur if the substitution effect of a reduction in the price of

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[24] An unrestricted subsidy could be anti-natalist because of the assumption that parents consume child services directly and numbers of children and investments in children only indirectly. Thus, if the demand for child services by parents were sufficiently unresponsive (inelastic) to changes in the price of child services, parents could end up having fewer children, investing more schooling in each child, and "producing" child services at relatively unchanged levels.

[25] Were it feasible to finance these investments through taxation, any positive income effects associated with these policies would be much reduced. However, this seems an unlikely source of funding in most LDC's especially from the income levels at which we are most interested in influencing fertility.

child investments outweighs the concommitant income effect.[26]

To my knowledge, empirical work appropriate for calculating the net effect on fertility of an educational subsidy is not now available. There is, however, some indication of the degree to which parents appear to trade off child schooling and numbers of children. In a recent paper (De Tray, forthcoming) I estimate the rate at which parents "give up" numbers of children for another year of schooling per child using U.S. household data.[27] The results offer strong support for the trade-off hypothesis, although the magnitudes, themselves, are not believable.[28] Holding constant income, parent wage rates and schooling levels, and certain occupational information about the father, a 10% increase in average per child schooling levels is associated with a 30% decrease in family size. These results were highly statistically significant.

There was no obvious way in my data (The National Longitudinal Survey for men aged 45-59) to determine whether this trade-off resulted from the relative price structure faced by couples in the sample, or whether it was a reflection of taste differences. However, the important point in the context of this conference is that the quantity-quality trade-off hypothesis passed its first direct test. And it did so in a manner that suggests that policies aimed at influencing child schooling

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[26]There is a third dimension of the problem, the substitution that may take place between a couple's consumption of child services and their consumption of "standard of living," a factor which would work to increase family size. The final outcome of these forces is an empirical question of some complexity.

[27]The methodology for estimating these effects is complex because of the endogeneity of numbers of and investment in children, family income, and wife's wage.

[28]It appears likely that multicollinearity biased the estimated trade-off coefficients and possibly the t-ratios upward.

levels may have a quantitatively important secondary impact on population growth rates. The speculative nature of these results quite clearly underlines both the need for and the direction of future research to better assess the fertility reducing potential of child schooling policies.

RESEARCH DESIGN STRATEGIES

In designing an experiment to test and measure the effect of education on family size, it is important to keep in mind certain basic considerations. Although somewhat of a simplification, one could argue that strategies aimed at influencing couples' demand for children must generally fall into one (or more) of the following types:

1. Attempts to influence a couple's taste for children (a propaganda campaign).
2. Policies that make children more expensive to produce (a poll tax or bonus scheme).
3. Subsidization of close substitutes for the services that children supply to parents (farm implements or old age security).
4. Reduction of the uncertainty that accompanies demographic transition (insuring the survival of children).

I would, in general, advocate experiments that fall directly into one of these categories. Education-related experiments will tend to influence parents through more than one of these avenues, and may have important side effects, both positive and negative. For these reasons, it may be difficult to assess the value of educational policies in a

broader development context.[29]

For the sake of argument I will assume that the use of education to influence population is a politically appealing policy option in most LDC's. I have argued above that because of the lags and costs involved, tests of the parent education/family size relationship are probably best carried out directly on the individual avenues through which adult education is thought to affect fertility.[30] Because of this I will concentrate here on strategies that attempt to test the strength of the negative influence of child education on desired family size.

To design an effective child education/fertility experiment we must first have some notion as to why parents have many children and invest relatively little in each child, rather than the other way around. Obvious possibilities are that parents are ignorant of the rate of return to investing in their children, that parents would like

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[29] As an aside, I would hazard the guess that one of the potentially most fruitful and least costly ways of influencing fertility is through policies that fall into the fourth category listed above. While parents are likely to be both risk averse and to consider too few children a far more costly mistake than too many children, governments will view the situation in a more neutral and symmetric light. In a regime of rapidly declining mortality, the actuarial cost of insuring couples against having less than two surviving children should not be especially large. An alternative scheme is suggested by some of the work of Ethel Shanas et al. (1968) on old age security in the U.S. The Shanas study indicates that at least in the U.S. children most often help aged parents in time of transitory (unexpected) financial crisis. If this motive for having children is also at work in LDC's, governments--and social science researchers--may want to consider establishing some form of catastrophic insurance as a substitute for insurance supplied to parents by their children.

[30] Obvious examples are experiments that change market wage rates, especially of women, and experiments that alter the supply of contraceptive techniques and contraceptive knowledge.

to invest more schooling in their children, but cannot because of constraints on the supply of schooling, and finally, that given prices, income, and an uncertain future, having many poorly educated children is, in fact, an optimal strategy.

The major analytical issue is to determine whether an unconstrained subsidy to the schooling that parents give their children would cause a net reduction in the demand for numbers of children. One might, for example, consider ways of either increasing accessability to schools for rural parents or of otherwise subsidizing investments in children. These would be untied subsidizations aimed at measuring the net (income and substitution) effect of reducing the price of child schooling.

The basic plan could be very simple, for example, building a new or expanding an existing school facility where schooling is supply constrained. Or, the Finnigan-Sun Educational Incentives Project (1972) could be modified so that each (newly) married couple receives a certificate worth a certain number of years of child schooling beyond some socially determined minimum level of schooling. Parents could spend these certificates as they wished--all on one child or one year on each of n children. Schooling beyond the child years allocated to each family would presumably be supplied to parents at cost. Problems that may arise under this scheme are that it could be pro-natalist for couples who initially desired very few children, and that it requires a coordinated increase in the local supply of schooling, so that parents would believe in the value of the coupons. If parents are investing optimal amounts in their children (schooling is not supply constrained), then a different form of subsidy may be required (free or subsidized meals while at school, for example).

In the simplest case of increasing the supply of schooling, problems of experimental design would be mainly operational and not conceptual. Determining what couples would have done had there been no experiment will be one of the major problems. Even if two similar villages could be isolated, one as a control and one in which to carry out the experiment, the effect of subsidizing schooling on the timing of children must still be resolved. If it could be determined that there were no major incentives in the program for parents to alter the timing of their children, then a year-by-year comparison of age-specific births between the experimental village and the control village could indicate in a relatively short period of time whether increased child schooling will ultimately reduce completed family size.

V. CONCLUSIONS

In this paper I have outlined a micro-economic model of population growth and tried to consider, in a heuristic fashion, what this perspective on family behavior says about the relationship between education and fertility. The evidence I cite is generally incomplete, so any conclusions drawn must be considered highly tentative; with this caveat in mind, I will venture the following recommendations:

- The policy payoff to fertility-related research is unlikely to be anywhere higher than for research on the relationship between both parent and child education and family size. The potential of education as a policy instrument to influence family size is great, but our ignorance of the mechanisms through which education may affect fertility is also large.
- Based on a priori considerations and some empirical findings, adult education policies may not be the most promising avenue into which scarce public funds should be channelled. Costs will be high and lags between policy action and fertility reduction may be long. Policies that more directly influence wife's wages, a couple's contraceptive behavior, and the early health and nutrition of children may be a more effective and quicker means of reducing family size.
- The tradeoff that parents appear to make between the number of children they want and the investments they make in each child may be the key to middle- and longer-term

population policy in developing nations. The evidence is tentative, but it suggests that this trade-off may be quantitatively important and may be easily affected by public policy.

Finally, there is the issue of feasibility. A policymaker reading this paper might well throw up his hands in despair since, of course, developing nations would like to increase the amount of schooling and health investments that reach children for reasons entirely independent of population growth and family size. But, such policies are simply too expensive to be realistic options on a national scale. To this I would reply only that it is exactly this scarcity of resources that makes the payoff to continued research on policy instruments like education so high.

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